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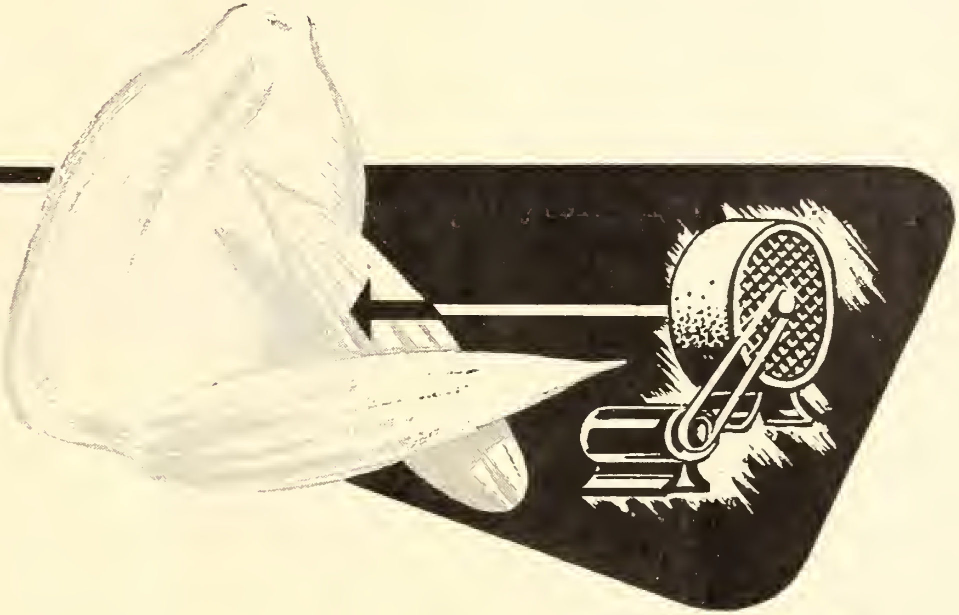
DRYING SHELLED CORN and SMALL GRAIN with UNHEATED AIR



Leaflet No. 332

U. S. DEPARTMENT OF AGRICULTURE

GRAIN DRYING ON THE FARM

Drying grain by mechanical ventilation removes many of the hazards of harvesting and storing crops. Such drying is valuable to you not only when you are faced with the emergency handling of high-moisture crops, but also as a part of your regular crop-management program. Controlled drying fits in with modern production, harvesting, and handling methods. It overcomes the problems presented by the use of grain combines and mechanical corn harvesters—equipment that gets the crops out of the field quickly but often dangerously wet. The availability of electric and gasoline-engine power and use of such power in driers of modern design makes mechanical ventilation possible.

Grain drying on the farm has the following advantages:

A. Corn can be—
   1. Stored safely.
   2. Marketed without a moisture discount.
   3. Harvested early, thus taking advantage of good harvesting weather, reducing field losses from insects and bad weather, obtaining cleaner husking, lowering harvesting costs, and making possible fall plowing and seeding of wheat or cover crops.
   4. Shelled and stored in tight bins in half the space required by ear corn, thus reducing storage losses caused by insects, rodents, and unfavorable weather.
   5. Harvested with a picker-sheller.
   6. Saved in wet years.

B. Small grains can be—
   1. Stored safely.
   2. Marketed without a moisture discount.
   3. Harvested as soon as mature, thus reducing the chance of storm damage while waiting for the crop to dry in the field.
   4. Harvested faster, by operating combines early in the morning and late at night.
   5. Combined directly, without windrowing.
   6. Saved even in wet harvesting weather, when, because of late seeding or poor growing weather, the crop must be harvested although it contains a high percentage of moisture.

The way to dry grain [1] is explained in this leaflet and the three others here listed, copies of which are available from your county agricultural agent, the Extension Service agricultural engineer at your State college, or from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.:

Leaflet 331, "Drying Shelled Corn and Small Grain with Heated Air," tells how you can use heat successfully to dry these crops on the farm.

Leaflet 333, "Drying Ear Corn with Heated Air," describes equipment needed and methods used in drying with heated air.

Leaflet 334, "Drying Ear Corn with Unheated Air," explains how unheated air can be forced through ear corn with good drying results and at low cost.

If drying crops with mechanical ventilation is new to you, the advantages and disadvantages listed below for both unheated- and heated-air drying may help you in considering your drying set-up.

Heated-Air Drying

Advantages:

1. Can dry wettest grain.
2. Can dry regardless of weather conditions.
3. Short drying time.
4. High drying capacity per fan horsepower.

Disadvantages:

1. Higher initial equipment cost.
2. Expense for fuel.
3. Some fire hazard.
4. Considerable supervision required.

Unheated-Air Drying

Advantages:

1. No expense for fuel.
2. No fire hazard.
3. Lower initial equipment cost.
4. Little supervision required.

Disadvantages:

1. Dependent on weather conditions.
2. Slow drying rate; usually several weeks.
3. With prolonged drying, grain may be damaged by mold growth.

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[1] How to dry forage crops is described in Farmers' Bulletin 2028, "Drying Forage by Forced Ventilation."

Washington, D. C.

Issued September 1952

Drying Shelled Corn and Small Grain With Unheated Air

MECHANICAL VENTILATION with unheated air is, under many conditions, an inexpensive method of drying grain. By this method, you can dry shelled corn or small grain in farm-type bins or general-purpose structures by installing duct systems or perforated false floors to insure the distribution of air uniformly through the grain. A crop-drying fan will be needed to circulate the unheated air through the grain. This method offers a reasonable protection to the quality of the grain under normal weather conditions.

In general, the recommendations in this leaflet apply to the Corn Belt and other areas with similar weather conditions and production practices. In drier areas, minimum air-flow requirements may be less than those given in this leaflet; in wetter areas, air-flow requirements will be higher.

General Recommendations

1. When filling the bin, spread any cracked grain and foreign material uniformly through the batch. Do not allow it to accumulate in spots.

2. Select ventilating equipment that will provide the required air flow at resistance pressures corresponding to the depth of grain through which the air will pass. The equipment should be capable of operating continuously at a constant rate for periods of 2 to 4 weeks, without frequent maintenance.

3. Provide for the uniform distribution of the drying air through the grain. There should be no appreciable loss in pressure in the duct system or perforated floor. Air may be either drawn or forced through the grain.

4. Supply air at a rate that will complete drying before the grain is damaged by mold growth or other causes. (For minimum air-flow requirements, see table 1.)

5. Start drying immediately after harvest and continue it until the moisture content of the grain is reduced to a safe storage level. The drying period may extend for 2 to 4 weeks, or perhaps longer in cool or wet weather.

6. For safe storage, dry shelled corn and small grain to about 13 percent moisture. If dried to only 14 or 15 percent, grain can be stored safely for only a few months during the cooler part of the year. Moisture content can be checked by testing samples with a grain moisture tester of the types used by local elevators.

7. When the moisture content of the grain is above 15 percent, supply air continuously, day and night. To reduce the moisture further after it has reached approximately 15 percent, limit ventilation to periods when the relative humidity of the air is less than 70 percent. The relative humidity will normally be below 70 percent between 10 a. m. and 6 p. m. on clear days.

Air-Flow Requirements

Grains Harvested in Warm Weather

Wheat, oats, and barley are harvested in the summer, when atmospheric conditions are relatively favorable for drying grain with unheated air. In northern areas, the harvest period may extend into late summer or early fall, when conditions are not so favorable.

Wheat

Wheat combined at a moisture content as high as 20 percent can be successfully dried with unheated air. Recommended minimum air-flow rates for drying wheat from various moisture levels are given in table 1.

Prepared by the Division of Farm Buildings and Rural Housing, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration. The research on which this publication is based was in cooperation with the agricultural experiment stations of Illinois, Iowa, and Indiana and with the Production and Marketing Administration, United States Department of Agriculture. Helpful suggestions were also received from agricultural engineers of other experiment stations, from the Rural Electrification Administration, United States Department of Agriculture, and from the manufacturers of crop driers and fans.

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Oats

A standard bushel of oats weighs only a little more than half as much as a bushel of wheat, so only about half as much water per bushel must be removed from oats as from wheat to effect the same percentage of moisture reduction. Sometimes it is desirable to harvest oats at a higher moisture content than wheat.

Recommended minimum air-flow rates for drying oats at four moisture levels are given in table 1. Oats have less resistance to air flow than wheat. Therefore, with the same size fan and air-flow rate, more bushels of oats than wheat can be dried.

Barley

A standard bushel of barley weighs 1½ times as much as a bushel of oats. So, more water must be removed from barley than from oats to obtain an equal percentage of moisture reduction. To remove the additional moisture, dry barley at a higher air-flow rate than for oats of the same moisture content; for example, dry 20 percent barley as you would 25 percent oats. Barley has about the same resistance to air flow as oats.

Grains Harvested in Cool Weather

Corn, soybeans, and grain sorghum are harvested in the fall. Because of the lower temperatures, these grains will have to be dried longer than those harvested in summer. On the other hand, the lower temperatures lessen the chance of mold damage.

Shelled Corn

With modern equipment, corn may be harvested and shelled at a moisture content as high as 30 percent. However, some mechanical damage to the kernels occurs when corn is shelled with conventional equipment. The damage may be excessive when the moisture is higher than 25 percent. Damaged or broken kernels are more subject to mold than are sound kernels.

The recommended minimum air-flow rates for drying shelled corn from various moisture levels are given in table 1. Shelled corn has less resistance to air flow than either oats or wheat. In power requirements, the lower resistance partly offsets the higher rates of air flow required to dry corn at the higher moisture levels.

Soybeans

Soybeans have the same bushel weight as wheat. Hence, an equal amount of water must be removed from each to obtain an equal percentage of moisture reduction. On the other hand, soybeans have less resistance to air flow than wheat; thus, more soybeans than wheat can be dried with the same size of fan unit and same air-flow rate per bushel. For safe storage, soybeans must be 1 to 2 percent lower in moisture content than wheat or corn.

Grain Sorghum

A bushel of grain sorghum weighs about the same as a bushel of shelled corn. So, about the same amount of water must be removed from each to obtain an equal percentage of moisture reduction. Grain sorghum has nearly twice as much resistance to air flow as shelled corn, however. Because of this the depth of grain sorghum in the drying bin should be only about two-thirds that recommended for corn of the same moisture content.

Ventilating Equipment

The ventilating equipment required for drying grain with unheated air consists of a fan and a power unit. The fan may be of either the propeller or the centrifugal type, and it must deliver the required volume of air against the static pressures indicated in table 1. Reliable manufacturers will supply air-delivery ratings for the range of static pressures for which their fan equipment is designed. Fans that are unsatisfactory for grain drying include house, attic, or barn ventilating fans; those for blowing materials, such as silage and grain blowers; and those of the type used in fanning mills.

Electric motors are recommended for use in drying grains. Gasoline engines may be used, but more labor will be required to attend and maintain them than for electric motors.

The number of bushels that can be dried per horsepower is reduced materially as the depth of grain is increased. On the other hand, the cost of building a structure with a greater floor area, in order to reduce the depth of the grain, will more than offset the lower power requirement.

By using table 1 you will be able to figure the fan horsepower required to dry wheat, oats, and corn from different percentages of moisture content and at various practical depths. Following is an example of the method used in figuring the fan horsepower required:

Suppose that one has a circular bin 18 feet in diameter or a rectangular bin 14 by 18 feet and that the shelled corn to be dried has a moisture content of 25 percent.

To compute the floor area of the circular bin, use the formula 3.14 times diameter squared divided by 4. Thus $\frac{3.14\times(18)^2}{4}=254.3$ square feet. To compute the floor area of the rectangular bin, multiply the dimensions—14 by 18 feet—which gives 252 square feet.

Table 1 shows that the greatest practical depth for drying shelled corn of 25 percent moisture content is 6 feet.

The volume of shelled corn in a bin 18 feet in diameter, when filled to a depth of 6 feet is 1,526 cubic feet, obtained by multiplying 254.3 square feet (floor area) by 6 feet (depth of grain).

The capacity in bushels, approximately 1,220, is obtained by dividing 1,526 cubic feet (volume of the bin) by 1.25 cubic feet (the volume of a bushel).

Table 1 shows that 380 is the maximum number of bushels of shelled corn of 25 percent moisture, and 6 feet deep, that should be dried per fan horsepower. Divide 1,220 (the capacity of bin in bushels) by 380 (number of bushels to dry per horsepower). The answer, 3.2, is the number of horsepower required to dry the batch of 1,220 bushels.

Use a 3-hp. motor and a suitable fan. The 3.2 hp. required to dry the corn is within the 10-percent overload permissible with a 3-hp. motor.

When buying the 3-hp. fan unit, remember that it must deliver 5 cubic feet per minute (c. f. m.) of air (table 1) for each bushel, or about 6,000 c. f. m. total; also, that the unit must be able to deliver the air against about 1.6 inches static pressure (table 1).

This same fan equipment will dry other crops at depths at which the bushels per fan horsepower total 380 or more. According to table 1, you can dry a 6-foot depth of wheat from 20 percent moisture, and at least a 10-foot depth of oats from 18 percent, but only about 6 feet of oats from 25 percent.

With a bin of 250 square feet of floor area, little is gained by using more than 3 hp. on the fan. You would be able to increase the depth of corn of 25-percent moisture less than 1 foot by increasing the motor size to 5 hp. A 5-hp. motor, if already available, can be used, however, under conditions similar to those described in the example, with little added operating cost. The purchase of a motor of this size is justifiable if it can also be used for other jobs.

TABLE 1.—*Fan requirements for drying oats, shelled corn, and wheat with unheated air from different percentages of moisture content and at various practical depths*

Grain moisture content (percent)	Recommended minimum air-flow rate per bushel	Practical grain depths	Static pressure[1]	Maximum quantity that can be dried per fan horsepower[2]
	Cubic feet per minute	*Feet*	*Inches, water gage*	*Bushels*
		WHEAT		
20	3	4	1.2	830
		6	2.3	440
18	2	4	.8	1,880
		8	2.5	600
16	1	8	1.3	2,300
		10	2.0	1,500
		OATS		
25	3	4	0.8	1,250
		6	1.7	590
20	2	6	1.1	1,360
		8	1.8	830
18	1½	8	1.4	1,430
		10	2.0	1,000
16	1	8	.9	3,330
		12	1.9	1,580
		SHELLED CORN		
25	5	4	0.7	860
		6	1.6	380
20	3	6	.9	1,120
		8	1.5	670
18	2	6	.6	2,500
		8	.9	1,670
		12	2.2	680
16	1	8	.5	6,000
		12	1.0	3,000
		16	1.6	1,880

[1] Static pressure includes 0.25 inch allowance for loss from duct friction.

[2] Air flow (c. f. m.) per horsepower based on 3,000 c. f. m. of air at 1-inch static pressure.

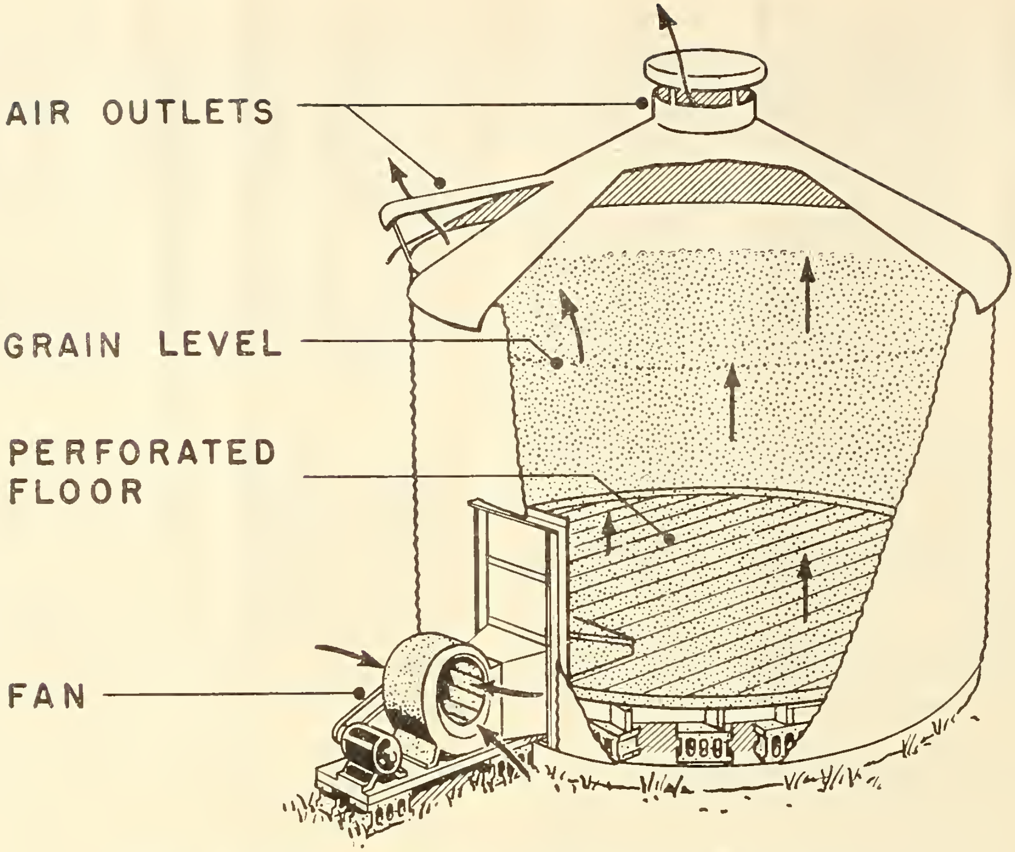


Figure 1.—*Circular metal bin with false floor of perforated metal.*

Use of the Same Equipment for Drying Other Crops

Fans and motors for drying shelled corn and small grains may also be used to dry ear corn and forage, although the equipment may be smaller than recommended for those crops. If you wish to dry more than one kind of crop with the same fan equipment, select the equipment that will meet the requirements of the most difficult job.

Adapting Storage Bins

Most farm bins can be readily adapted for drying grain with unheated air. Figures 1 to 5, inclusive, illustrate methods of adapting common types of bins and general-purpose buildings for such drying. Fan units may be installed either to draw the unheated air through the grain or to force the air through.

The false floor of the circular metal bin shown in figure 1 is perforated metal. Cover the floor with an even layer of grain so that the unheated air will be distributed uniformly through the grain. Recommended grain depths are from 4 to 10 feet. If a conveyor is to be used beneath the perforated floor, place this floor at least 16 inches above the permanent floor or ground. If a portable auger is to be used on top of the false floor, make the height of the false floor 10 to 12 inches. Support this floor on wood framing and concrete blocks or on other suitable supports. Lay the blocks so that air can circulate through the openings. Provide one block for each 50 bushels of grain that can be placed in the bin. Perforations should amount to at least 7 percent of the total area of the false floor. It is best to mount the perforated floor in removable sections so that the space under the false floor may be cleaned easily.

Several companies make the perforated metal sheets for false floors. You can get plans for installing the floors from these companies. Perforated metal floors can also be used in other types of bins.

Hardware cloth, as shown in figure 2, can be used instead of perforated metal sheets, as material for false floors in drying bins. If openings are too large to hold the grain, cover the cloth with screen wire. Lay the concrete blocks so that air will circulate through them. Rows of blocks laid 3 feet apart will support grain to a depth of 15 feet; rows 4½ feet apart will support grain to a depth of 9 feet. Provide 1 block for each bushel of grain.

A duct system that can be used in many types of bins is shown in figure 3. The duct system can be used in circular and rectangular bins, in overhead bins of combination crib-granaries, and in bins in a granary. For uniform air distribution fill the bin with grain to a depth of at least 3 feet. The main duct, shown in figure 3 in the middle of the bin, could be located along one side, either inside or outside of the bin. Build the lateral ducts in about 4- to 6-foot sections, so that you can remove them easily while emptying the bin. Details on construction of the duct system are shown in figure 4.

Construction details for a duct system that can be used in several types of bins, as just described, are shown in figure 4. The main duct is generally rectangular in shape, although it may be rounded or triangular. Allow 1 square foot of cross section area for each 1,500 c. f. m. of air flow from the fan. For example: If the fan delivers air at the rate of 6,000 c. f. m., the cross section area of the main duct should be at least 4 square feet. The duct could be 2 feet square or a triangle with 3-foot sides. Provide small screened openings along the top of the main duct so that air may pass upward to dry grain above.

Space the lateral ducts, which can be rectangular, triangular, or rounded in shape, so that the distance between them (center to center) is not more than one-half the depth of grain to be dried. If all the lateral ducts are the same length, compute the cross section area required for each by dividing the cross section area of the main duct by the number of lateral ducts. For example: With 8 laterals of the same length and a main duct cross section area of 4 square feet, the cross section area of each lateral will be 4 divided by 8, or ½ square foot.

The width of each lateral should be at least twice the height of its bottom edge above the floor. This height should be about 4, 6, 7, 8, and 10 inches for laterals spaced 2, 3, 4, 5, and 6 feet, respectively, from center to center.

In any case the total area for air passage under all the lateral ducts (height from floor to bottom of lateral times length of both sides) should be equal to at least one-fourth of the bin floor area.

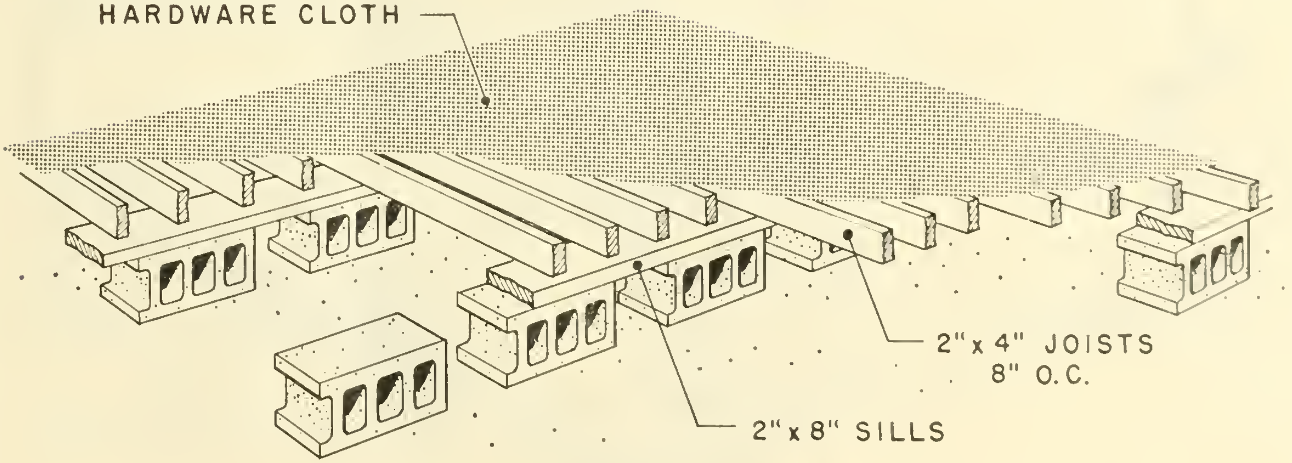


Figure 2.—*Hardware cloth used as a false floor in a bin.*

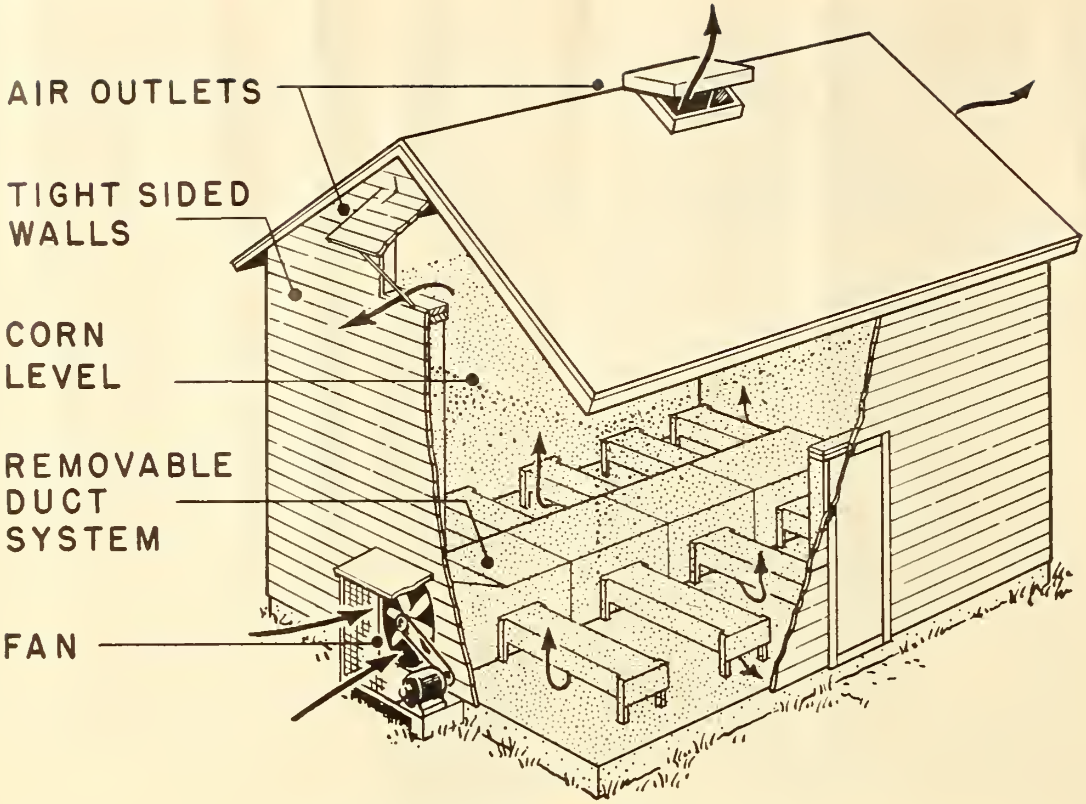


Figure 3.—*Rectangular bin with duct system.*

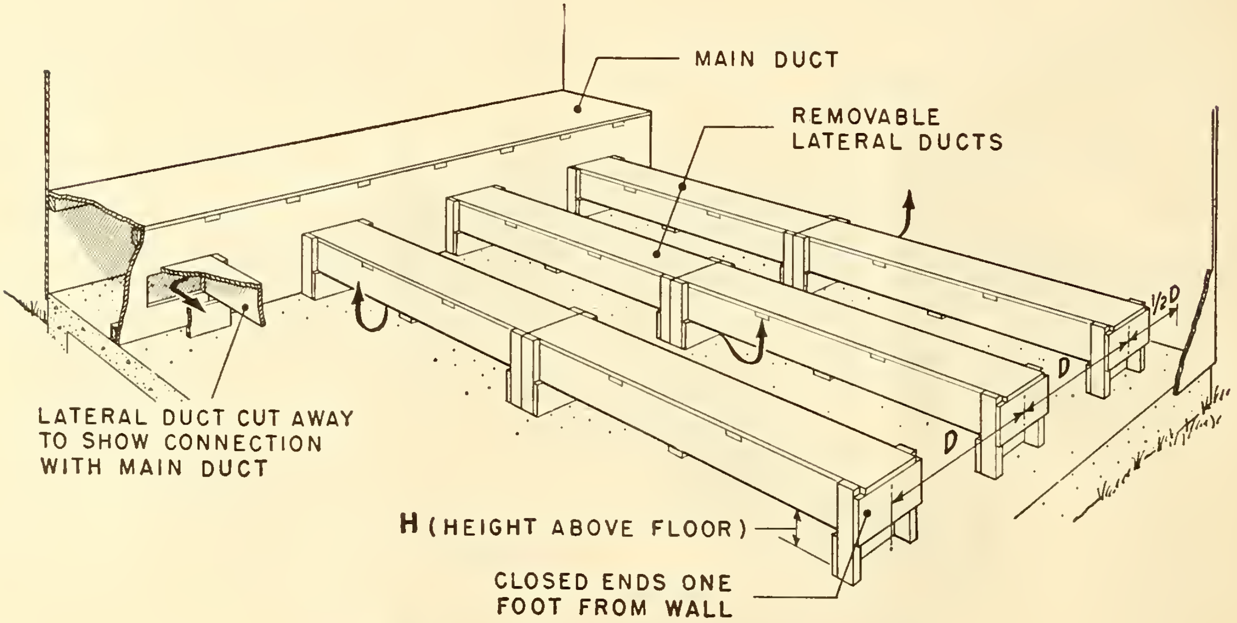

MAIN DUCT
REMOVABLE LATERAL DUCTS
1/2D
D
D
LATERAL DUCT CUT AWAY TO SHOW CONNECTION WITH MAIN DUCT
H (HEIGHT ABOVE FLOOR)
CLOSED ENDS ONE FOOT FROM WALL

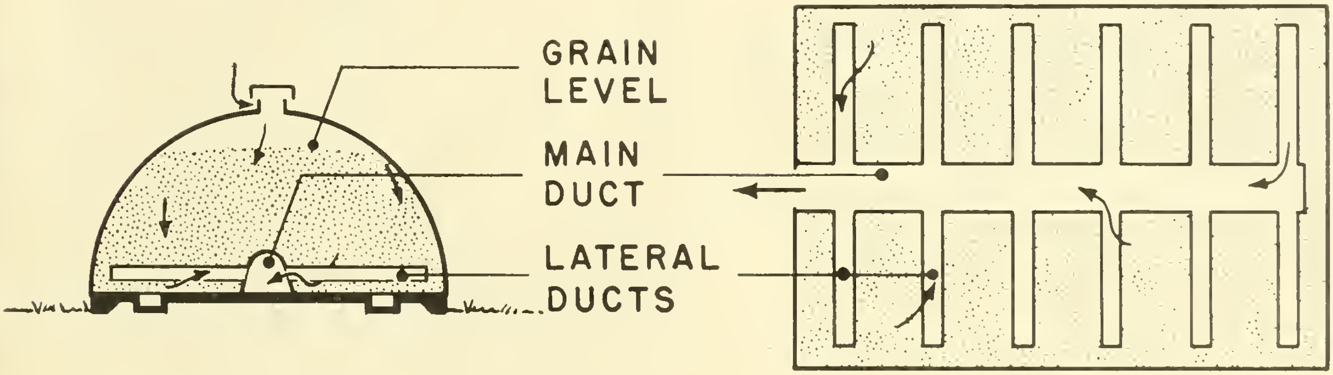
Figure 4.—*Details of duct system for drying bin.*

If you use perforated metal sheets to make the laterals, and the sheets have uniformly spaced perforations equaling at least 10 percent of their total area, you may set the laterals directly on the bin floor.

Installation of a duct or tunnel system will enable you to dry and store grain in a prefabricated general-purpose building of the type shown in figure 5. General-purpose buildings are made of either metal or wood. Some have straight sides instead of arched ribs. Distribute grain evenly over the ducts before starting the fan. Information for figure 4 tells how to build and install the main duct and laterals. With air moving downward as shown, the wettest grain will be near the floor. Samples should be drawn with a grain probe to determine when this bottom grain is dry. If the drying air moves upward, the wettest grain is at the top.

Estimating Costs of Drying

Drying costs will include both the operating cost for power and labor and the overhead cost of equipment. The power cost will depend on the initial moisture content of the grain, weather conditions during the drying period, and the depth and kind of grain ventilated. At 3 cents per kilowatt hour, the power cost in well-designed drying systems is usually between 1 and 4 cents per bushel.



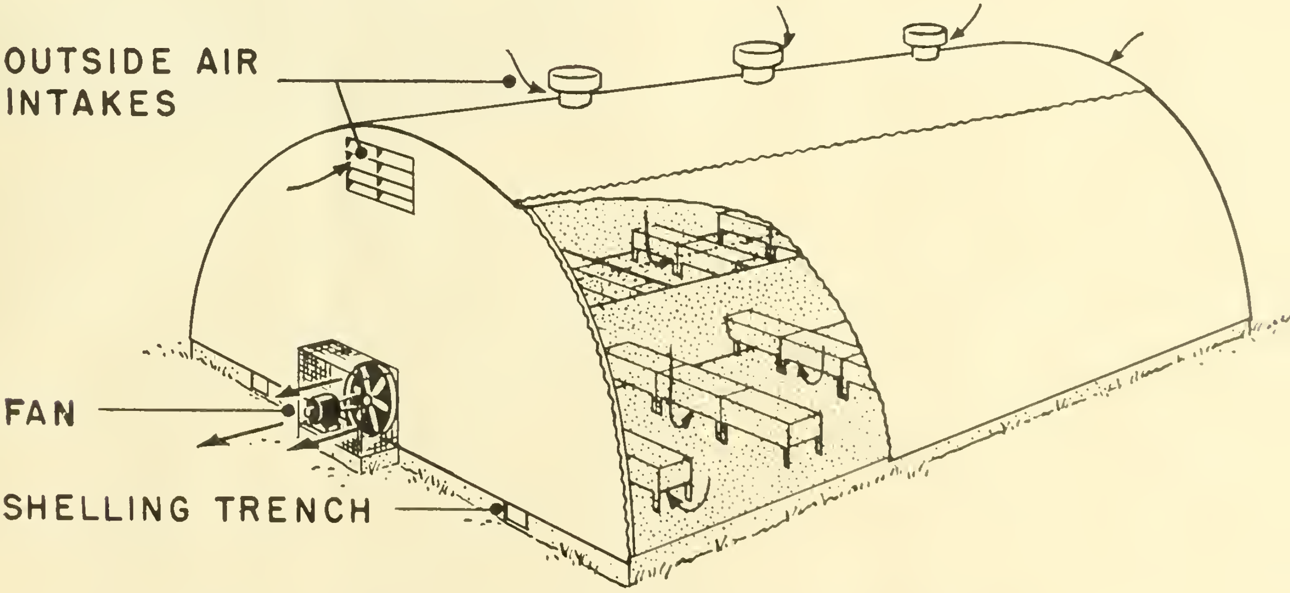


Figure 5.—*General-purpose building arranged for drying and storing grain.*

Weight Loss Caused by Moisture Reduction

Table 2 shows the amount of water in grains at various percentages of moisture content. By using this table you can estimate the weight loss (number of pounds of water evaporated) caused by drying. Subtract the weight of water per bushel after drying from the weight of water per bushel at the start of drying.

Another method of calculating weight loss is by the following formula:

$$\text{Initial weight} \times \frac{\text{100 minus initial percent moisture}}{\text{100 minus final percent moisture}}$$

=final weight. Then, initial weight minus final weight=weight of water lost.

For example, if 20,000 pounds of grain with a moisture content of 25 percent is dried down to 13 percent, the weight after drying will be $20{,}000 \times \frac{\text{100 minus 25}}{\text{100 minus 13}} = 20{,}000 \times \frac{75}{87} = 20{,}000 \times 0.86 =$ approximately 17,200 pounds. This is a weight loss of 2,800 pounds (weight of water lost by evaporation).

Table 2.—*Pounds of water per bushel*[1] *of grain at different moisture-content percentages*[2]

Grain moisture content (percent)	Amount of water per bushel of—		
	Shelled corn and grain sorghum (Pounds of dry matter per bushel=47.32)	Wheat and soybeans (Pounds of dry matter per bushel=51.6)	Oats (Pounds of dry matter per bushel=27.4)
	Pounds	*Pounds*	*Pounds*
35	25.4	27.8	14.6
30	20.2	22.1	11.7
28	18.4	20.1	10.6
26	16.6	18.2	9.6
24	14.9	16.4	8.6
22	13.3	14.6	7.7
20	11.8	12.9	6.8
18	10.4	11.4	6.0
16	9.0	9.8	5.2
14	7.7	8.4	4.4
12	6.5	7.0	3.7
10	5.3	5.8	3.0
8	4.1	4.5	2.3

[1] A bushel is defined here as the amount of grain required to yield 56 pounds of shelled corn or grain sorghum at 15.5 percent moisture, 60 pounds of wheat or soybeans at 14 percent, and 32 pounds of oats at 14.5 percent.

[2] To determine the number of pounds of grain required to make a bushel at a given moisture percentage, add the pounds of water to the pounds of dry matter (shown at head of column). For example: To obtain the weight of corn, at 28-percent moisture content, to make a bushel, add the pounds of water (18.4) to the pounds of dry matter per bushel (47.32). This totals 65.7 pounds. It requires 65.7 pounds of corn at 28-percent moisture content to make a bushel (56 pounds) of 15.5 percent corn.

U. S. GOVERNMENT PRINTING OFFICE: 1952

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